EMDF Comments Primarily Related to Radionuclide Discharge Limits
Water Quality Protection of Bear Creek Fact Sheet
Due DOE June 7, 2022

Submitted to: OakRidgeEM@orem.doe.gov
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Subject: Comments primarily related to the Water Quality Protection of Bear Creek fact sheet concerning discharge limits for radionuclides including values and how they are calculated referenced on page 1 of the fact sheet

On November 4, 2021, several former TDEC employees sent a letter concerning the Environmental Management Disposal Facility (EMDF) to EPA Administrator Michael S. Regan. The December 29, 2021, response from Acting Assistant Administrator Barry N. Breen stated the EPA, DOE, and TDEC will solicit and consider public comments on new information before EPA and DOE finalize the ROD. This letter encouraged us to review the new information that will be added to the Administrative Record file as well as provided to the public on a dedicated website. The website includes the following new information:

EMDF Site Groundwater Characterization fact sheet

EMDF Waste Acceptance Criteria fact sheet

EMDF Water Quality Protection for Bear Creek fact sheet

Draft Record of Decision – July 2021

Draft 1 ROD Responsiveness Summary

Technical Memo #1: Phase 1 Field Sampling Results (July 2, 2018)

Technical Memo #2: Phase 1 Monitoring (May 23, 2019)

Development of Fish Tissue and Surface Water Preliminary Remediation Goals (April 28, 2022) (EMDF PRG Development)

Performance Assessment for the Environmental Management Disposal Facility at the Y-12 National Security Complex, Oak Ridge, Tennessee (April 23, 2020) (EMDF Performance Assessment)

Composite Analysis for the Environmental Management Waste Management Facility and the Environmental Management Disposal Facility, Oak Ridge, Tennessee (April 16, 2022)

Link to the Oak Ridge Environmental Information System (OREIS)

1) These comments on the Water Quality Protection for Bear Creek fact sheet identify a series of complexities, uncertainties, and issues associated with discharging landfill wastewater containing radionuclides from the proposed Environmental Management Disposal Facility (EMDF) to surface water. A conclusion from these comments is that failure of the Record of Decision to require effective treatment for radionuclides in landfill wastewater before discharge to surface water would show a preference for minimizing treatment cost over ensuring protection of human health.

2) EPA Administrator Andrew R. Wheeler's December 31, 2020, final dispute decision concerning the *Focused Feasibility Study for Water Management for the Disposal of CERCLA Waste on the Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-2664&D2) and discharge of radionuclides to Bear Creek surface water is new information substantive to the Water Quality Protection for Bear Creek fact sheet and determining radionuclide discharge levels and should have been included on the dedicated website.
3) During DOE's presentation on the fact sheets at the May 17, 2022, public meeting, DOE's presenter said that they will be putting basically the same stuff in the proposed new landfill (i.e., EMDF) as the current facility (i.e., EMWMF). As was pointed out by at least one commentor, who retired from Oak Ridge National Laboratory (ORNL), the proposed site will receive waste from ORNL which is significantly different than most of the previous disposed waste.

To clarify further, the Environmental Management Waste Management Facility (EMWMF) is not indicative of a future Environmental Management Disposal Facility (EMDF). K-25 (East Tennessee Technology Park or ETTP), Y-12, and X-10 (Oak Ridge National Lab or ORNL) have different radionuclide and Clean Water Act (CWA) pollutant waste profiles. K-25 (ETTP) has been the major focus for many years and is the source of most of the recent waste disposed in the EMWMF. Wastes from Y-12 and ORNL proposed to be disposed in a future EMDF are orders of magnitude more contaminated with CWA pollutants (e.g., Y-12 - mercury) and radionuclides than wastes from ETTP disposed in the EMWMF. Radionuclide activity concentrations in EMDF landfill wastewater are also projected to be orders of magnitude greater than radionuclide activity concentrations measured in EMWMF landfill wastewater. The EMDF Performance Assessment[i] and EMWMF/EMDF Composite Analysis[ii] show that waste disposed in EMWMF is not indicative of future waste proposed to be disposed at EMDF. DOE proposes to dispose a significantly greater inventory of radionuclides at EMDF than EMWMF.

Radionuclide Inventory Identified for Disposal in EMDF is Significantly Greater than Radiological Inventory Disposed at EMWMF			
	EMDF/EMWMF Composite Analysis Table B.1		EMDF Performance Assessment Table B.6[iii]
Isotope Name	Reported EMWMF Activity at FY 19 (Curies)	Composite Analysis Estimated Waste Inventory Activity at EMWMF Closure (Curies)	EMDF Estimated Waste Inventory Activity at closure for a subset of Radionuclides (Curies decayed to 2047)
Am-241	20.2	25.5	152
C-14^	2.77	3.5	7.43
Cm-244	-----	-----	326
Cs-137	-----	-----	3040
Eu-152	-----	-----	74
Eu-154	-----	-----	16.7
H-3^	12.1	15.3	28.8
I-129^	0.00115	0.00145	1.05
K-40	-----	-----	8.46
Ni-63	-----	-----	1740
Np-237	1.4	1.77	0.837
Pb-210	-----	-----	9.5
Pu-238	-----	-----	242
Pu-239/240	14	18	310
Pu-241	-----	-----	525
Pu-242	-----	-----	0.445

Ra-226	-----	-----	2.07
Sr-90	-----	-----	496
Tc-99^	170	215	7.23
Th-229	-----	-----	14.7
Th-230	-----	-----	4.94
Th-232	-----	-----	9.07
Th-234*	-----	-----	-----
U-232	-----	-----	26.3
U-233/234	433	547	1727
U-235/236	42	53	125.2
U-238	258	326	983

^Radionuclides that EMDF PA Table G.9 adjusts for activity loss due to leaching during the 25-year operational period.
*Th-234 should be in secular equilibrium with U-238.

Further, average leachate activity concentrations projected in the EMDF Performance Assessment at landfill closure are significantly greater than maximum leachate and contact water activity concentrations measured at EMWMF from October 2015 through June 2021.

Comparison of Maximum Measured Activity Concentration in EMWMF Leachate and Contact Water for the period of October 2015 to June 2021 with the Average Leachate Activity Concentration Projected in EMDF at Closure.			
	Maximum Activity Concentration Measured from October 2015 through June 2021 and Reported in OREIS Data		EMDF Projected Leachate Activity Concentrations at EMDF Landfill Closure
Isotope Name	EMWMF Leachate (pCi/L) Activity concentration >1 rounded to a whole number	EMWMF Contact Water (pCi/L) Activity concentration >1 rounded to a whole number	EMDF Performance Assessment Table C.5. at T=0 (pCi/L)
Am-241	0.708	0.245	29
C-14	20	22	2,450
Cm-244	Undetected at 0.473	Undetected at 0.201	6,230
Cs-137	5	Undetected at 5.89	787
Eu-152	14	16	1,420
Eu-154	9	6	321
H-3	10300	4,790	21,000
I-129	3	2	158
K-40	65	67	215
Ni-63	65	53	673
Np-237	Undetected at 0.207	0.685	16
Pb-210	2	0.987	73
Pu-238	Undetected at 0.457	Undetected at 0.458	4,640
Pu-239/240	Undetected at 0.235	Undetected at 0.364	5,950
Pu-241	Undetected at 47.5	Undetected at 18.6	10,100
Pu-242	Undetected at 0.476	Undetected at 0.286	9
Ra-226	1	1	0.5
Sr-90 / radioactive strontium	44 (Sr-90)	8 (radioactive strontium - total)	12,600 (Sr-90)
Tc-99	2120	28,500	2,690
Th-229	Undetected at 0.503	Undetected at 0.241	4
Th-230	2	0.586	1
Th-232	0.201	0.361	2
Th-234*	28	41	

U-232	0.455	Undetected at 0.263	404
U-233/234	2200	676	26,650
U-235/236	226	48	1,926
U-238	100	41	15,100

*Th-234 should be in secular equilibrium with U-238.

4) TDEC contracted with Neptune and Company, Inc. to evaluate the EMDF Performance Assessment (PA). Neptune's review[iv] states *uncertainty in the inventory of disposed radionuclides is likely to be one of the more significant sources of uncertainty in the PA results.* This means there is significant uncertainty in how much of what radionuclides will be disposed in the proposed EMDF.
5) CERCLA at 42 U.S. Code § 9621(d)(1) requires that "Remedial actions selected under this section or otherwise required or agreed to by the President under this chapter shall attain a degree of cleanup of hazardous substances, pollutants, and contaminants released into the environment and of control of further release at a minimum which assures protection of human health and the environment." (Emphasis added) Plain reading of CERCLA at 42 U.S. Code § 9621(d)(1) should forbid a remedial action consisting of building a combination hazardous waste, toxic waste, and radioactive waste landfill; consolidating waste in the landfill; and then releasing or discharging landfill wastewater containing radionuclides and pollutants to surface water in a manner that does not protect human health (e.g., results in exceeding the 10^{-4} and 10^{-6} CERCLA risk range or a hazard index of 1) and does not protect the environment. The Water Quality Protection for Bear Creek fact sheet states Bear Creek joins with East Fork Poplar Creek, then flows into Poplar Creek and eventually enters the Clinch River. For EMDF, protection of human health and the environment applies to any stream reach downstream of EMDF whether it is in Bear Creek, East Fork Poplar Creek, Popular Creek, or the Clinch River. Radionuclides without fish tissue and corresponding water quality PRGs in the EMDF PRG Development[v] document would appear to be able to be discharged pursuant to DOE Orders up to Derived Concentration Standard (DCS) values. Consumption of fish were not considered in derivation of DCS values. Radiation Risk Assessment at CERCLA Sites: Q & A, Directive 9200.4-40, EPA 540-R-012-13, May 2014 specifies "[a]t CERCLA remedial sites, excess cancer risk from both radionuclides and chemical carcinogens should be summed to provide an estimate of the combined risk presented by all carcinogenic contaminants as specified in OSWER directive 9200.4-18 (U.S. EPA 1997a)." It is not demonstrated in the Water Quality Protection for Bear Creek fact sheet or the supporting EMDF PRG Development that the combined release of carcinogenic chemical pollutants (e.g., PCBs) and radionuclides will not result in exceeding the CERCLA required risk range.
6) Radionuclides without fish tissue and corresponding water quality PRGs in the EMDF PRG Development document would appear to be able to be discharged from EMDF pursuant to DOE Orders up to Derived Concentration Standard (DCS) values. Consumption of fish were not considered in derivation of DCS values. These radionuclides are not exempt from complying with the 10-5 cancer risk level relevant and appropriate requirement and contributing to the total cancer risk compared to the CERCLA risk range.
7) EPA Administrator Wheeler's December 31, 2020, final dispute resolution designated regulations that establish water quality based effluent limitations under the Clean Water Act National Pollution Discharge Elimination System program as well as Tennessee 's NPDES regulations for establishing water quality-based effluent limitation, certain Tennessee Water Quality Standards regulations, and certain Nuclear Regulatory Commission regulations for low-level radioactive waste disposal as relevant and appropriate requirements for discharge of

radionuclides from CERCLA landfills at the Oak Ridge Reservation. Several relevant and appropriate requirements include:

a) **TDEC Rule 0400-40-05-.08(1) EFFLUENT LIMITATIONS AND STANDARDS**

(g) *All pollutants shall receive treatment or corrective action ... to insure compliance with any approved water quality standard, …*

(k) All permit effluent limitations, standards, and prohibitions shall be established for each outfall or discharge point of the permitted facility, except as otherwise provided for BMPs where limitations on effluent or internal waste streams are infeasible.

(m) For continuous discharges, all permit effluent limitations, standards, and prohibitions shall be expressed as maximum daily, weekly average (for POTWs only) and monthly average, unless impracticable.

(n) Non-continuous discharges shall be limited in terms of frequency, total mass, maximum rate of discharge, and mass or concentrations of specified pollutants, as appropriate.

(q) When permit effluent limitations or standards imposed at the point of discharge are impractical or infeasible, effluent limitations or standards for discharges of pollutants may be imposed on internal waste streams before mixing with other waste streams or cooling water streams. In those instances, the monitoring required shall also be applied to the internal waste streams. Limits on internal waste streams will be imposed only when the rationale sets forth the exceptional circumstances which make such limitations necessary, such as when the final discharge point is inaccessible (for example, under water), the wastes at the point of discharge are so diluted as to make monitoring impracticable, or the interferences among pollutants at the point of discharge would make detection or analysis impracticable.

(r) Instantaneous maximum concentration or similar limitations may be imposed in permits when: 1. Toxic or harmful parameters are present in such significant amounts or concentrations as to represent a threat to the possibility of maintaining receiving waters in accordance with established classifications; and 2 The discharge is characterized as irregular, such as high peak, short duration flow.

(s) *Any discharge or activity authorized by a permit which is not a minor discharge or activity, or the regional administrator requests, in writing, be monitored, or contains a toxic pollutant for which an effluent standard has been established shall be monitored by the permittee for the following: 1. Flow (in million gallons per day); and 2. Any of the following pollutants: (i) Pollutants (either directly or indirectly through the use of accepted correlation coefficients or equivalent measurements determined to be applicable to the discharge to which they are applied) which are subject to reduction or elimination under the terms and conditions of the permit; (ii) Pollutants which the commissioner finds, on the basis of information available, could have a significant impact on the quality of waters; (iii) Pollutants specified by the administrator, in regulations issued pursuant to the Federal Water Pollution Control Act, as subject to monitoring; and (iv) Any pollutants, in addition to*

those identified in subparts (i) through (iii) of this part, which the regional administrator or the Commissioner request be monitored

b) **TDEC Rule 0400-40-05-.10 WATER QUALITY-BASED PERMITTING** (1) *Effluent limitations on toxic substances will be required in accordance with the General Water Quality Criteria, Chapter 0400-40-03, using the LC50 and/or IC25 criteria and appropriate application factor for each toxic parameter*

c) **TDEC Rulee 0400-40-10-.03(3) Text of Cited Federal Regulations 40 CFR § 122.45 Calculating NPDES permit conditions (applicable to State NPDES programs, see § 123.25)**

(a) Outfalls and discharge points. All permit effluent limitations, standards and prohibitions shall be established for each outfall or discharge point of the permitted facility, except as otherwise provided under § 122.44(k) (BMPs where limitations are infeasible) and paragraph (i) of this section (limitations on internal waste streams).

(d) Continuous discharges. For continuous discharges all permit effluent limitations, standards, and prohibitions, including those necessary to achieve water quality standards, shall unless impracticable be stated as:
(1) Maximum daily and average monthly discharge limitations for all dischargers other than publicly owned treatment works;

(e) Non-continuous discharges. Discharges which are not continuous, as defined in § 122.2, shall be particularly described and limited, considering the following factors, as appropriate:

(1)Frequency (for example, a batch discharge shall not occur more than once every 3 weeks);

(2) Total mass (for example, not to exceed 100 kilograms of zinc and 200 kilograms of chromium per batch discharge);

(3) Maximum rate of discharge of pollutants during the discharge (for example, not to exceed 2 kilograms of zinc per minute); and

(4) Prohibition or limitation of specified pollutants by mass, concentration, or other appropriate measure (for example, shall not contain at any time more than 0.1 mg/L zinc or more than 250 grams (¼ kilogram) of zinc in any discharge).

(f) Mass limitations.

(1) All pollutants limited in permits shall have limitations, standards or prohibitions expressed in terms of mass except:

(i) For pH, temperature, radiation, or other pollutants which cannot appropriately be expressed by mass;

(ii) When applicable standards and limitations are expressed in terms of other units of measurement; or

(iii) If in establishing permit limitations on a case-by-case basis under § 125.3, limitations expressed in terms of mass are infeasible because the mass of the pollutant discharged cannot be related to a measure of operation (for example, discharges of TSS from certain mining operations), and permit conditions ensure that dilution will not be used as a substitute for treatment.

(2) Pollutants limited in terms of mass additionally may be limited in terms of other units of measurement, and the permit shall require the permittee to comply with both limitations.

(h) Internal waste streams

(1) When permit effluent limitations or standards imposed at the point of discharge are impractical or infeasible, effluent limitations or standards for discharges of pollutants may be imposed on internal waste streams before mixing with other waste streams or cooling water streams. In those instances, the monitoring required by § 122.44(i) shall also be applied to the internal waste streams.

(2) Limits on internal waste streams will be imposed only when the fact sheet under § 124.56 sets forth the exceptional circumstances which make such limitations necessary, such as when the final discharge point is inaccessible (for example, under 10 meters of water), the wastes at the point of discharge are so diluted as to make monitoring impracticable, or the interferences among pollutants at the point of discharge would make detection or analysis impracticable.

d) **TDEC Rule 0400-40-03-.03(4)(j)** Recreation use paragraph (4)(j) water quality standards are based on 10^{-5} excess lifetime cancer risk for individual contaminants (or groups of contaminants, e.g., Total PCBs)
e) **TDEC Rule 0400-40-03-.05(4)** specifies discharge requirements in permits for discharge to surface water designated as recreational use are based on 30-day minimum five-year recurrence interval stream flow. (This may be estimated by USGS StreamStats.)
f) **TDEC Rule 0400-40-03-.05(6)** All discharges of sewage, industrial waste, and other waste shall receive the degree of treatment or effluent reduction necessary to comply with water quality standards.
g) **TDEC Rule 400-40-03-.03(4)(l)** Fish Consumption Advisories - A public fishing advisory will be considered when the calculated risk of additional cancers exceeds 10-4 for typical consumers or 10-5 for atypical consumers
h) **TDEC Rule 0400-40-03-.05(2)** … Mixing zones shall not apply to the discharge of bioaccumulative pollutants to waters of the state where the risk-based factors in Rule 0400-40-03-.03(4)(l) are exceeded for the pollutant group.
i) **Rule 0400-40-03-.03 (3) The criteria for the use of Fish and Aquatic Life**

(d) Turbidity, Total Suspended Solids, or Color - There shall be no turbidity, total suspended solids, or color in such amounts or of such character that will materially affect fish

and aquatic life. In wadeable streams, suspended solid levels over time should not be substantially different than conditions found in reference streams.

(g) Toxic Substances - The waters shall not contain substances or a combination of substances including disease - causing agents which, by way of either direct exposure or indirect exposure through food chains, may cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including malfunctions in reproduction), physical deformations, or restrict or impair growth in fish or aquatic life or their offspring.

(m) Biological Integrity - The waters shall not be modified through the addition of pollutants or through physical alteration to the extent that the diversity and/or productivity of aquatic biota within the receiving waters are substantially decreased or, in the case of wadeable streams, substantially different from conditions in reference streams in the same ecoregion. The parameters associated with this criterion are the aquatic biota measured. These are response variables.

j) **Rule 0400-40-05-.10 WATER QUALITY-BASED PERMITTING.**
   (1) Effluent limitations on toxic substances will be required in accordance with the General Water Quality Criteria, Chapter 0400-40-03, using the LC50 and/or IC25 criteria and appropriate application factor for each toxic parameter.
   (2) Appropriate limitations on organic related and other oxygen demanding parameters will be required in any permit to insure adequate dissolved oxygen in the state's waters in accordance with the General Water Quality Criteria, Chapter 0400-40-03.
   (3) When a treatment process greater than BAT or conventional unit treatment processes is required by application of these rules, a set of effluent limitations will be required in any permit which will completely describe expected results of such treatment process.
   (4) Effluent limitations may be required in any permits to insure compliance with the Antidegradation Statement, Rule 0400-40-03-.06.

k) **EPA Administrator Wheeler's December 31, 2020, final dispute decision** requires apportioning dose to various sources under NRC regulations and using ALARA to ensure that application of a NRC regulation also achieves a risk level no less stringent than 10^{-5} (Final Dispute Decision Pages 2 and 7 with reference to footnote 20.)

8) **The Water Quality Protection for Bear Creek fact sheet specifies the goal is to establish discharge levels safe for recreational use. That is an important exposure pathway for this site. However, CERCLA requires protection of both human health and the environment. The Record of Decision should also ensure protection of the environment as demonstrated through effluent toxicity testing, biological integrity monitoring, and other appropriate measures.**

9) Once the Record of Decision includes activity concentrations for radionuclides in fish that relate to 10-5 cancer risk for Bear Creek, it is likely those activity concentrations will also be applied to East Fork Poplar Creek, Poplar Creek, and Clinch River. The quantity of fish consumed from Bear Creek should be significantly lower than the quantify of fish consumed from East Fork Poplar Creek, Poplar Creek, and the Clinch River meaning using Bear Creek fish ingestion rates for these downstream streams likely underestimates how much fish is consumed and the associated cancer risk. EMDF PRG Development[vi] references a non-promulgated TDEC instream

value as justification to reduce the fish ingestion rate value from 155.9 grams per day to 17.5 grams per day in Table A.2. Joanna Burger & Kym Rouse Campbell (2008) *Fishing and consumption patterns of anglers adjacent to the Oak Ridge Reservation, Tennessee: higher income anglers ate more fish and are more at risk,* Journal of Risk Research, 11:3, 335-350, DOI:10.1080/13669870701795560 includes an evaluation of people fishing and consuming fish caught in the Clinch River and in Poplar Creek in the area of the confluence of East Fork Poplar Creek down to the Clinch River. Pollution and radionuclides discharged into Bear Creek should move downstream with surface water into East Fork Poplar Creek, Poplar Creek, and the Clinch River. **The 17.5 gram/day fish consumption rate is less than the mean (37 +/- 6 grams/day) identified in Joanna Burger & Kym Rouse Campbell (2008) for people who consume fish caught in the Clinch River and Poplar Creek and therefore does not represent a reasonable maximum exposure for these downstream water bodies. The evaluation of consumption of fish under CERCLA in lower East Fork Poplar Creek, Poplar Creek, and the Clinch should at least be based on the upper end of the mean developed by the site-specific study (e.g., 42 grams of fish per day) or, even better, the default CERCLA reasonable maximum exposure of 54 grams of fish per day.**

10) EPA Administrator Wheeler's December 31, 2020, final dispute decision requires that *"Cleanup levels for discharges of carcinogens from a NPL site also cannot be less stringent than the CERCLA risk range."* This did not say cleanup levels from a remedial action, it says cleanup levels from a NPL site. That means the cumulative[vii] of all carcinogenic chemical (e.g., PCBs) and radionuclide cleanup levels for discharges from the NPL site shall be apportioned so that the resulting cancer risk is not less stringent than the CERCLA risk range[viii]. With the number of radionuclides present, this likely results in the need to reduce discharge limits for individual radionuclides to levels less than the 10-5 cancer risk level.

11) In addition to the recreational fishing pathway, incidental ingestion of uranium as a metal by young children playing in Bear Creek should be included in the Water Quality Protection for Bear Creek fact sheet and EMDF PRG Development as an additional exposure pathway.

a) Radiation Risk Assessment At CERCLA Sites: Q & A, Directive 9200.4-40 EPA 540-R-012-13, May 2014 states: *Uranium, in soluble form, is a kidney toxin at mass concentrations slightly above background levels. It is the only radionuclide for which the chemical toxicity has been identified to be comparable to or greater than the radiotoxicity and for which an oral reference dose (RfD) has been established to evaluate chemical toxicity. To properly evaluate human health risks, both effects (radiogenic cancer risk and chemical toxicity) should be considered for radioisotopes of uranium.*

b) Using uranium activity for in stream surface water in EMDF PRG Development Table 1, a total uranium concentration of about 836 ug/L may be calculated.

Radionuclide	EMDF PRG Development Table 1 Proposed Surface Water instream PRG in pCi/L	PRG in ug/L Calculated with www.radprocalculator.com/Grams.aspx
U-233/U-234 (Calculated as U-234)	317	5.11E-8 grams/liter 0.051 ug/L
U-235/U-236	455	0.000211 grams/liter

(Calculated as U-235)		211 ug/L
U-238	210	0.000625 grams/liter 625 ug/L
Total Uranium	-------	836 ug/L

c) TN H_2O[ix] TENNESSEE'S ROADMAP TO SECURING THE FUTURE OF OUR WATER RESOURCES includes *"Tennessee's climate is changing .... Average annual rainfall is increasing, and a rising percentage of that rain is falling on the four wettest days of the year .... The data clearly indicate an increasing trend in precipitation across Tennessee. This trend is expressed by more frequent heavy rainfall, and greater annual precipitation amounts, contrasted with dry spells that are more likely to be more severe because very hot days will be more frequent - even though annual precipitation is increasing."*

d) With more frequent very hot days, it is possible that families with young children (i.e., children age less than 6 years) will utilize Bear Creek (e.g., at the greenway) as an area to cool down. At a total uranium concentration of 836 ug/L in Bear Creek surface water, young children playing in surface water for only 11 to 36 hours per year approximates a non-carcinogenic hazard quotient of 1. Hazard quotients were calculated using default values (e.g., child incidental ingestion rate) in https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search. With increasing temperature associated with climate change, exposure to children playing in the Bear creek to cool down should be evaluated as an exposure pathway.

12) I support the fish sampling program included in the Water Quality Protection for Bear Creek fact sheet coupled with timely public notification of results and contingencies to control exposure and to attain a degree of control of further release[x] at a minimum which assures protection of human health and the environment. Initiating a fish sampling program in Bear Creek for radionuclides was a positive outcome of EPA Administrator Andrew R. Wheeler's December 31, 2020, final dispute decision on the Focus Feasibility Study for Water Management. The Water Quality protection for Bear Creek fact sheet includes, *"Though not expected, if future monitoring identifies fish tissue levels approaching protective limits, DOE will implement additional protective measures."* Given the levels of radionuclides in waste projected for disposal (EMDF Performance Assessment Table B.5.), the levels of radionuclides projected to be in EMDF landfill wastewater at closure in FY2047 (EMDF Performance Assessment Table C.5), and the described wastewater treatment with chemical flocculation/precipitation and sediment removal, I don't understand why either exceeding the 10-5 excess lifetime cancer risk for individual radionuclides or the CERCLA risk range for the cumulative of carcinogenic chemicals and radionuclides is not expected. The question should not be if these levels are exceeded, but when will these levels be exceeded? Of course, radionuclides not sampled for will be missed and not included in the evaluation of compliance with the 10-5 cancer risk recreational use relevant and appropriate requirement or evaluation of the CERCLA cumulative risk. It is suggested that there be comprehensive sampling of radionuclides in landfill wastewater and that the fish sampling program be updated at least annually to include additional radionuclides identified in landfill wastewater. Unfortunately, this process is like closing the barn door after the horse has already left the barn. Many radionuclides have half-lives sufficient that when the radionuclides have accumulated in fish, it will take many years for the radionuclides to either decay to levels that are protective of human health or to not be available in the food web.

Table B.5. Arithmetic average activity concentrations for EMDF waste streams

	EMDF waste stream average activity concentration (pCi/g)					
Radioisotope	ORNL D&D	ORNL RA	Y-12 D&D Alpha-4 and Alpha-5	Y-12 D&D Biology	Y-12 D&D Remaining Facilities	Y-12 RA
Ac-227	3.88E-02					
Am-241	2.10E+02	6.14E+02	1.61E-02	1.82E-01	5.96E-02	6.86E-01
Am-243	2.73E+00	3.95E+01				
C-14	8.53E+00	2.55E+01		4.18E+01		
Cf-249	1.44E-05					
Cf-250	9.82E-05					
Cf-251	2.79E-06					
Cf-252	1.74E-06					
Cm-243	5.18E+00	5.65E-01				
Cm-244	1.67E+03	1.40E+01	3.93E-03			
Cm-245	5.08E-01					
Cm-246	2.11E+00					
Cm-247	1.38E-01					
Cm-248	7.43E-03					
Co-60	2.18E-01	4.38E-02	6.47E-03			7.98E-04
Cs-134	2.79E-08	1.21E-07				
Cs-137	2.11E+03	1.46E+04	1.99E-01	1.32E-01	4.68E-02	5.40E+00
Eu-152	3.73E+02	8.08E+00				
Eu-154	8.49E+01	1.39E+00				
Eu-155	8.87E-02	7.95E-04				
Fe-55		1.28E-05				
H-3	1.30E+02	1.97E+01		2.23E+00		
I-129	4.92E+00	5.18E-01				
K-40	5.53E+00	1.90E+01		2.23E+01		6.33E+00
Mo-100	5.58E-05					
Na-22	1.08E-05	1.45E-07				
Nb-94	2.16E-01					
Ni-59	4.04E+01					
Ni-63	6.02E+02	8.97E+03		1.72E+00		
Np-237	4.59E-01	2.81E+00	4.90E-02	2.15E-01		4.32E-01
Pa-231	3.17E+00					
Pb-210	4.68E+01	2.26E+00				
Pm-146	1.17E-03					
Pm-147	2.83E-03	9.38E-05				
Pu-238	7.37E+02	5.46E+02	1.84E-01		3.95E-01	8.77E-03
Pu-239	2.37E+02	5.76E+02			7.62E-02	5.93E-01
Pu-240	3.51E+02	5.08E+02	6.77E-02	1.80E-01		
Pu-241	6.87E+01	2.83E+03				
Pu-242	1.83E-01	2.27E+00				
Pu-244	4.89E-02					
Ra-226	2.92E+00	3.92E+00		9.97E-01		1.45E+00

Table B.5. Arithmetic average activity concentrations for EMDF waste streams (cont.)

	EMDF waste stream average activity concentration (pCi/g)					
Radioisotope	ORNL D&D	ORNL RA	Y-12 D&D Alpha-4 and Alpha-5	Y-12 D&D Biology	Y-12 D&D Remaining Facilities	Y-12 RA
Ra-228	6.54E-03	1.39E-02			1.71E-01	2.68E-03
Re-187	2.27E-05					
Sb-125	4.02E-07					
Sr-90	2.16E+03	4.15E+02		1.75E+00	1.66E-01	
Tc-99	1.32E+01	3.94E+00	1.08E+00	4.06E+01	7.78E-01	4.61E+00
Th-228	1.16E-06	1.88E-09	5.93E-07	1.27E-05	1.58E-05	
Th-229	1.73E+00	7.96E+01			4.71E-02	
Th-230	1.70E+00	2.11E+01	4.32E-01		7.85E-02	1.37E+00
Th-232	1.19E+00	9.36E+00	3.74E-01	7.96E-01	6.54E-01	1.31E+01
U-232	8.34E-01	1.45E+02				
U-233	2.65E+02	2.92E+02		9.65E+01	1.10E+00	
U-234	1.11E+01	1.51E+02	9.10E+00	8.33E+01	5.23E+03	1.56E+01
U-235	4.20E-01	2.34E+00	7.47E-01	7.18E+00	3.16E+02	1.11E+01
U-236	2.65E-01	1.08E+00	3.80E-01	4.23E+00	7.47E+01	2.26E-01
U-238	6.79E+00	2.92E+01	3.43E+01	3.40E+02	2.91E+03	1.51E+02

D&D = deactivation and decommissioning
EMDF = Environmental Management Disposal Facility
ORNL = Oak Ridge National Laboratory
RA = remedial action
Y-12 = Y-12 National Security Complex

13) The fish sampling program and risk calculations assume people only cook and eat fish fillets. I don't know if this protects people who cook whole fish or eat other portions of fish.
14) Even though Administrator Wheeler's December 31, 2020, final dispute resolution to the Focus Feasibility Study for Water Management "*determined that* [Clean Water Act (CWA)] *technology-based effluent limitations are not appropriate requirements to apply to a discharge of radionuclides from this CERCLA site*" there are multiple lines of evidence that demonstrate that effective treatment of radionuclides will be needed at a new EMDF to ensure protection of human health required by CERCLA. The following comments concern lines of evidence that effective water treatment for radionuclides should be required in the Record of Decision for all wastewater released from a future EMDF.

15) The Water Quality Protection for Bear Creek fact sheet proposes using fish sampling to determine if either enhanced water treatment or restricting waste streams to the EMDF landfill are necessary. This means detection limits of radionuclides in fish and associated rad error must be low enough to make an irrefutable determination whether the 10-5 cancer risk level is exceeded.

    The following table includes Fish PRG activities from *Development of Fish Tissue and Surface Water Preliminary Remediation Goals for Radionuclides of Interest for the Proposed Environmental Management Disposal Facility, Oak Ridge, Tennessee* (UCOR-5550) dated 4-28-22 (EMDF PRG Development) Table 1 and ranges of detection limits and radiological error for fish samples in the Oak Ridge Environmental Information System (OREIS) database for the 5-year period of calendar year (CY) 2017 through CY 2021. Several additional radionuclides of interest are also included in the following table. Note that some PRGs are within the range of laboratory detection limits and sample radionuclide error. For these radionuclides, at least part of the time, it will be undeterminable whether the 10-5 cancer risk level relevant and appropriate requirement is exceeded. Radium-226 (Ra-226) and Radium-228 (Ra-228) PRGs were always

exceeded by detection limits. These radionuclides are identified in the following table in bold red font.

International Atomic Energy Agency April 2015 freshwater to fish transfer values are also included in the table for reference. Given equal activities of radionuclides in surface water and other variables, the greater the freshwater to fish transfer factor the more of the radionuclide that should be expected to transfer from surface water into fish.

Isotope	Fish Tissue PRG TR=10-5 EMDF Development Table1* (pCi/g)	Aquatic Animal Detection Limit range in OREIS for fish collected from CY2017 through CY2021 (pCi/g)	Aquatic Animal Rad Error range in OREIS for fish collected from CY2017 through CY2021 (pCi/g)	IAEA April 2015 Geometric Mean BCF Values (L/kg)
Am-241	0.451	0.007 to 0.093	0.00269 to 0.0249	5.7E+02
C-14	30.1	1.96 to 5.75	1.15 to 3.38	6.8E+04
Cl-36	13.6	0.248 to 0.862	0.135 to 0.521	1.3E+03
Co-60	2.7	0.0386 to 1.47	0.0196 to 0.847	7.4E+01
Cs-137	**1.61**	**0.0296 to 2.88**	**0.189 to 1.69**	**1.7E+03**
Eu-154	4.25	0.092 to 0.954	0.0359 to 0.477	4.5E+01
H-3	418	0.0131 to 19.9	0.0594 to 12.3	
I-129	**0.306**	**0.0203 to 2.32**	**0.0104 to 1.18**	**2.0E+02**
Np-237	0.656	0.00205 to 0.156	0.000786 to 0.0781	
Pu-238	0.355	0.0034 to 0.0396	0.00107 to 0.0128	1.4E+02
Pu-239/240	0.346	0.00338 to 0.0969	0.00141 to 0.0388	1.4E+02
Ra-226	**0.0152**	**0.0311 to 0.413**	**0.0282 to 0.318**	**6.1E+01**
Ra-228	**0.0422**	**0.0531 to 0.994**	**0.0231 to 0.59**	**6.1E+01**
Sr-90	0.632	0.0174 to 0.492	0.0109 to 0.347	1.5E+02
Tc-99	15.1	0.377 to 3.86	0.224 to 2.12	7.1E+01
Th-228	**0.142**	**0.021 to 0.16**	**0.00447 to 0.104**	**1.2E+02**
Th-230	0.505	0.0249 to 0.221	0.0104 to 0.0663	1.2E+02
Th-232	0.452	0.00591 to 0.131	0.00374 to 0.035	1.2E+02
U-233/234	0.559	0.0057 to 0.0917	0.00277 to 0.041	1.0E+01
U-235/236	0.601	0.00502 to 0.0967	0.00199 to 0.03312	1.0E+01
U-238	0.499	0.00406 to 0.0905	0.0019 to 0.041	1.0E+01
Additional Radionuclides of Interest				
Ra-226 (individual)	**0.117**	**0.0311 to 0.413**	**0.0282 to 0.318**	**6.1E+01**
Ra-228 (individual)	**0.0423**	**0.0531 to 0.994**	**0.0231 to 0.59**	**6.1E+01**
Pb-210 (individual)	**0.0512**	**0.0337 to 1.34**	**0.0202 to 0.653**	**1.0E+02**
Po-210	0.0267	No data	No data	5.9E+02
Pb-210 (SE)	**0.0175**	**0.0337 to 1.34**	**0.0202 to 0.653**	
K-40	**1.76**	**0.244 to 44.7**	**0.458 to 78.6**	**4.7E+03**

*These PRGs were calculated assuming someone eats an average of 17.5 grams of fish per day. For downstream East Fork Poplar Creek, Poplar Creek, and Clinch River this likely underestimates the amount of fish eaten by a factor of about 3 meaning these fish tissue PRGs may need reducing to a third of these values to evaluate risk from eating fish downstream.

16) To determine whether additional treatment is needed, it will also be necessary to determine whether the cancer risk is greater than 10-5 over naturally occurring risk levels. Consider Ra-226. Ra-226 is important because EMDF PRG Development proposed that Ra-226 is in secular equilibrium with its progeny Pb-210 and Po-210 and analysis for Pb-210 and Po-210 isotopes would not be needed. Ra-226, Pb-210, and Po-210 are of concern because each poses a 10-5 cancer risk to people consuming fish at very low activities in fish. Ra-226 data for lower Bear Creek, East Fork Poplar Creek between Bear Creek and Poplar Creek, and the reference reach (BFK 7.6) for CY 2021 available from the Oak Ridge Environmental Information System (OREIS) are included in the endnote[xi]. EMDF PRG Development Table 1 shows a Ra-226 activity in fish of 0.0152 pCi/g equates to a 10-5 cancer risk and it would therefore be necessary to determine a 0.0152 pCi/g activity increase in fish to classify the activity as not naturally occurring. As shown in the above comment, rad measurement error in fish samples analyzed for Ra-226 should be expected in the range of 0.0282 to 0.318 pCi/g. With the range of detects and associated rad measurement error in the reference reach, Bear Creek, East Fork Poplar Creek, an increase of 0.0152 pCi/g over background appears indistinguishable. Without being able to irrefutably determine a 0.0152 pCi/g increase in Ra-226 activity concentrations over the background reference stream, ensuring compliance with ARARs and protection of human health required by CERCLA are not met.

17) It is possible to mathematically calculate the risk from consumption of fish contaminated with radionuclides that relate to specific concentrations of radionuclides in waste disposed in the EMDF landfill. However, results of the calculations depend on assumptions and uncertainties, and it is undeterminable whether calculated activities in fish and surface water represent actual conditions in a specific water body or stream reach. For example, identification of radionuclides in waste, activities of radionuclides in waste disposed, assumed soil and waste to water partitioning coefficients (kd), dilution of landfill wastewater in the receiving stream, activities of radionuclides in surface water, physiological status of fish (e.g., rapidly growing fish may accumulate higher levels of biologically active radionuclides than fish in stationary growth periods (Argonne National Laboratory (ANL) RESRAD Data Collection Handbook[xii])), transfer of radionuclides from freshwater to fish, bioconcentration or bio-dilution of radionuclides in the food web, parent-progeny relationships, radioactive half-live and decay, how long fish live in water contaminated with radionuclides, what parts of fish are eaten, how fish are prepared, quantity of fish eaten, and other factors likely influence the cancer risk to people who consume fish contaminated by radionuclides released from a future EMDF.

18) As an example, consider freshwater to fish transfer factors. The April 2015 summary table of freshwater to fish transfer values is available from the International Atomic Energy Agency (IAEA) at www.wildlifetransferdatabase.org. This summary is given below and shows that the difference in maximum and minimum freshwater to fish transfer values for some radionuclides may vary by 3 to 5 orders of magnitude (i.e., factors of 1,000 to 100,000). Freshwater to fish transfer factors applicable to various habitats in Bear Creek and downstream are unknown.

IAEA Freshwater to Fish Transfer Values (L/kg)								
Wildlife	**Radionuclide**	**Arithmetic Mean**	**Arithmetic SD**	**Geomean**	**Geo SD**	**Min**	**Max**	**n**
Fish	**Al**	1.2E+02	2.3E+02	**5.3E+01**	3.5E+00	1.0E+00	1.5E+03	400

Fish	**Am**	7.6E+02	6.7E+02	**5.7E+02**	2.1E+00	2.4E+00	1.5E+03	17
Fish	**As**	2.7E+02	3.7E+02	**1.5E+02**	2.8E+00	5.8E+00	2.0E+03	221
Fish	**Au**	6.3E+01	9.4E+01	**3.5E+01**	2.9E+00	1.3E+01	2.4E+02	14
Fish	**Ba**	1.7E+02	2.7E+02	**9.3E+01**	3.1E+00	3.0E-01	1.4E+03	640
Fish	**C**	1.8E+05	4.4E+05	**6.8E+04**	4.1E+00	1.0E+03	4.0E+06	85
Fish	**Ca**	1.4E+03	1.8E+03	**8.9E+02**	2.6E+00	1.6E+01	1.6E+04	511
Fish	**Cd**	2.1E+03	1.3E+04	**3.3E+02**	6.8E+00	5.7E+00	1.1E+05	282
Fish	**Ce**	1.7E+02	3.9E+02	**6.8E+01**	3.9E+00	1.8E+00	2.3E+03	306
Fish	**Cl**	1.3E+03	3.8E+02	**1.3E+03**	1.3E+00	1.3E+02	1.8E+03	17
Fish	**Cm**	2.4E-01	3.0E-09	**2.4E-01**	1.0E+00			7
Fish	**Co**	2.6E+02	9.0E+02	**7.4E+01**	4.9E+00	7.4E-01	9.0E+03	571
Fish	**Cr**	2.0E+02	1.4E+02	**1.6E+02**	1.9E+00	3.0E-01	9.0E+02	531
Fish	**Cs**	3.6E+03	6.8E+03	**1.7E+03**	3.4E+00	1.3E+01	8.2E+04	752
Fish	**Cu**	4.0E+02	4.2E+02	**2.8E+02**	2.3E+00	3.1E+00	2.8E+03	793
Fish	**Dy**	1.6E+02	1.6E+02	**1.1E+02**	2.3E+00	4.0E+01	4.2E+02	16
Fish	**Er**	9.4E+01	1.1E+02	**6.2E+01**	2.5E+00	1.8E+01	2.5E+02	13
Fish	**Eu**	6.5E+01	6.6E+01	**4.5E+01**	2.3E+00	6.2E+00	2.9E+02	82
Fish	**Fe**	5.6E+02	1.2E+03	**2.4E+02**	3.6E+00	6.4E-01	8.0E+03	904
Fish	**Ga**	9.2E+02	7.6E+02	**7.1E+02**	2.0E+00	3.8E+02	1.9E+03	11
Fish	**Gd**	1.2E+03	0.0E+00	**1.2E+03**	1.0E+00			4
Fish	**Hf**	6.5E+02	0.0E+00	**6.5E+02**	1.0E+00			4
Fish	**Hg**	3.5E+02	5.6E+02	**1.9E+02**	3.1E+00	2.7E+01	1.0E+03	3
Fish	**Ho**	1.4E+02	1.9E+02	**8.7E+01**	2.7E+00	3.1E+01	4.6E+02	16
Fish	**I**	3.1E+02	3.7E+02	**2.0E+02**	2.6E+00	9.0E+00	1.3E+03	165
Fish	**K**	6.6E+03	6.4E+03	**4.7E+03**	2.3E+00	2.4E+02	4.7E+04	312
Fish	**La**	1.3E+02	2.6E+02	**5.9E+01**	3.5E+00	3.3E-01	1.5E+03	280
Fish	**Li**	1.2E+01	6.1E+00	**1.1E+01**	1.6E+00	8.0E+00	2.2E+01	16
Fish	**Lu**	4.7E+02	3.7E+02	**3.7E+02**	2.0E+00	2.0E+02	9.4E+02	11
Fish	**Mg**	1.6E+02	2.0E+02	**9.7E+01**	2.7E+00	4.1E+00	9.7E+02	183
Fish	**Mn**	2.9E+03	1.7E+04	**5.2E+02**	6.5E+00	3.3E+00	2.6E+05	1050
Fish	**Mo**	2.2E+01	4.2E+01	**9.8E+00**	3.5E+00	1.8E-01	3.1E+02	385
Fish	**Na**	2.0E+02	2.3E+02	**1.3E+02**	2.5E+00	2.0E+00	9.8E+02	410
Fish	**Nb**	3.2E+01	1.1E+01	**3.1E+01**	1.4E+00	2.3E+01	5.5E+01	25
Fish	**Nd**	2.8E+02	3.2E+02	**1.9E+02**	2.5E+00	2.9E+01	7.9E+02	16
Fish	**Ni**	2.0E+02	3.5E+02	**9.9E+01**	3.3E+00	1.6E+00	3.0E+03	430
Fish	**P**	6.8E+05	2.5E+05	**6.4E+05**	1.4E+00	3.5E+05	1.2E+06	163
Fish	**Pb**	3.6E+02	1.2E+03	**1.0E+02**	4.9E+00	2.0E+00	9.3E+03	606
Fish	**Po**	2.0E+03	6.6E+03	**5.9E+02**	4.8E+00	4.9E+01	3.7E+04	203
Fish	**Pr**	7.3E+03	0.0E+00	**7.3E+03**	1.0E+00			4
Fish	**Pu**	8.3E+02	4.9E+03	**1.4E+02**	6.6E+00	4.0E-01	4.7E+04	106
Fish	**Ra**	1.8E+02	5.0E+02	**6.1E+01**	4.4E+00	1.4E-01	4.8E+03	295
Fish	**Rb**	4.5E+04	5.3E+04	**2.9E+04**	2.5E+00	1.9E+03	2.0E+05	49
Fish	**Re**	3.3E+01	8.1E+00	**3.2E+01**	1.3E+00	2.1E+01	3.8E+01	10
Fish	**Ru**	1.0E+02	3.5E+02	**2.9E+01**	4.9E+00	1.7E-01	1.4E+03	17
Fish	**Sb**	4.0E+01	9.4E+01	**1.5E+01**	4.0E+00	2.4E-01	7.5E+02	181
Fish	**Sc**	3.3E+00	3.6E+00	**2.2E+00**	2.4E+00	9.2E-01	7.4E+00	15
Fish	**Se**	2.6E+03	3.6E+03	**1.6E+03**	2.8E+00	8.8E+00	1.4E+04	413
Fish	**Sm**	3.5E+02	3.1E+02	**2.6E+02**	2.1E+00	4.4E+01	7.7E+02	16
Fish	**Sn**	4.8E+02	3.2E+02	**4.0E+02**	1.8E+00	1.9E+02	1.1E+03	19

Fish	**Sr**	8.6E+02	4.8E+03	**1.5E+02**	6.4E+00	3.8E+00	1.2E+05	925
Fish	**Ta**	2.6E+01	5.1E+00	**2.6E+01**	1.2E+00	2.1E+01	3.0E+01	7
Fish	**Tb**	5.4E+02	4.0E+02	**4.3E+02**	1.9E+00	2.5E+02	1.2E+03	16
Fish	**Tc**	9.9E+01	9.6E+01	**7.1E+01**	2.3E+00	5.3E+00	2.0E+02	3
Fish	**Te**	3.3E+02	2.1E+02	**2.8E+02**	1.8E+00	9.6E+01	8.9E+02	15
Fish	**Th**	7.1E+02	4.3E+03	**1.2E+02**	6.7E+00	3.3E+01	3.7E+04	73
Fish	**Ti**	6.8E+02	1.4E+03	**3.0E+02**	3.6E+00	6.7E+00	6.1E+03	196
Fish	**Tl**	4.2E+03	3.8E+03	**3.1E+03**	2.2E+00	1.0E+02	1.3E+04	48
Fish	**Tm**	1.8E+03	0.0E+00	**1.8E+03**	1.0E+00			4
Fish	**U**	7.2E+01	5.0E+02	**1.0E+01**	7.2E+00	5.1E-01	5.0E+03	1334
Fish	**V**	3.3E+01	3.4E+01	**2.2E+01**	2.4E+00	1.1E+00	2.2E+02	222
Fish	**W**	1.2E+03	0.0E+00	**1.2E+03**	1.0E+00			4
Fish	**Y**	9.0E+01	1.6E+02	**4.4E+01**	3.3E+00	2.5E-01	5.2E+02	36
Fish	**Yb**	1.0E+03	0.0E+00	**1.0E+03**	1.0E+00			4
Fish	**Zn**	7.9E+03	5.8E+03	**6.3E+03**	1.9E+00	1.6E+01	3.4E+04	882
Fish	**Zr**	1.3E+03	2.9E+03	**5.1E+02**	3.9E+00	9.2E+00	1.5E+04	77

19) EMDF PRG Development and the EMDF Performance Assessment use different bioconcentration factors for some isotopes. For example, EMDF PRG Development uses a BCF values from the ORNL Risk Assessment Information System (RAIS) of 0.96 L/kg for uranium isotopes and 6 L/kg for thorium isotopes. The EMDF Performance Assessment references a source with a uranium BCF of 10 L/kg. ANL RESRAD Onsite also uses a BCF value of 10 L/kg for uranium isotopes and IAEA 2015 freshwater to fish transfer factors includes 10 L/kg as the geometric mean for uranium. The ORNL RAIS references a 2010 IAEA report[xiii] as the basis for the 0.96 L/kg uranium BCF for fish muscle and said report shows the uranium BCF is a geometric mean of 9 samples with BCF values ranging from 0.2 to 20. The same 2010 IAEA report shows the 6 L/kg BCF for thorium was based on 3 samples. The following table compares the result for U-238 using BCF values for uranium of 0.96 L/kg and thorium of 6 L/kg with results from BCF values for uranium of 10 L/kg and thorium of 120 L/kg. The process followed is the same process used in the EMDF PRG Development.

This table shows the importance of BCF values. Basing the conversion of Th-234 activity in fish to surface water and vice versa on a BCF value based on only 3 samples is a gamble. If the gamble is wrong, it could result in cancer risks associated from U-238 and its progeny Th-234 on the order of 10-4 rather than 10-5 at the 211 pCi/L PRG. Further, Th-234 is not analyzed for in fish, so if the gamble is wrong, the cancer risk from Th-234 is hidden and not included in determining whether release of carcinogenic pollutants and radionuclides exceed the CERCLA risk range.

Thorium-234 has a half-life of 24.1 days and the reasonable maximum exposure should assume people eat the fish on the same day as caught.

With the uncertainty in BCF values, it is anticipated similar analysis could also be performed for other parent-progeny radionuclide groupings.

Comparison of U-238 PRGs using different BCF Values						
	Isotope	10-5 PRG in Fish in (pCi/g)	10-5 PRG in Fish in (pCi/kg)	BCF (L/kg)	PRG for Surface Water pCi/L	BCF Source
PRG	U-238	0.695	695	0.96	724	EMDF PRG Development (0.96) ORNL RAIS (0.96)
PRG	Th-234	1.770	1,770	6	295	EMDF PRG Development (6) ORNL RAIS (6)
Combined		0.499			210	
IAEA 2015	U-238	0.695	695	10	69.5	EMDF PA, (10) RESRAD (10) IAEA 2015 (10)
IAEA 2015	Th-234	1.770	1,770	120	14.8	EMDF PA (100) RESRAD (100) IAEA 2015 (120)
Combined		0.499			12	
PRG	U-238	0.695	695	0.96	724	EMDF PRG Development (0.96) ORNL RAIS (6)
IAEA 2015	Th-234	1.770	1,770	120	14.8	EMDF PA (100) RESRAD (100) IAEA 2015 (120)
Combined		0.499			15	
		Surface Water (pCi/L)	BCF (L/kg)	Fish (pCi/kg)	Fish (pCi/g)	Excess Cancer Risk
PRG	U-238	210	0.96	201.6	0.2	2.88E-06
IAEA 2015	Th-234	210	120	25,200	25.2	1.42E-04
Combined						**1.45E-04**

20) The EMDF Performance Assessment assumed a release where fish are only exposed to the radionuclide in surface water for 0.0001 year (i.e., mean residence time of about 53 minutes) in determining radionuclide concentrations in fish. For discharges of landfill wastewater to surface water from the proposed future EMDF during landfill operations through 2047 or later, discharges of radionuclides would occur either continually or in batches for the duration of landfill operations. That is, it is likely bioconcentation of some radionuclides could continue throughout the lifetimes of at least some species of fish.
21) We don't know what we don't know. Y-12 and X-10 (ORNL) are historic DOE facilities that date back to the Manhattan Project and are still operating. By its nature, there were secret and classified activities. Additional experiments at ORNL may have also likely taken place since the Manhattan Project. Potential carcinogenic contaminants or radionuclides in waste streams may exist that have not been identified or sampled for that, if present, may impact human health or the environment.

22) The EMDF Performance Assessment included screening source concentrations (Performance Assessment Table ES.2) and estimated leachate concentrations at landfill closure in FY 2047 (Performance Assessment Table C.5).

Screening source concentrations are based on arithmetic averages of all available Oak Ridge data, including maximum and upper confidence limit values, without correction for decay prior to EMDF closure.

Source leachate concentrations are aqueous activity concentrations of radionuclides in pCi/L calculated in Appendix C of the EMDF Performance Assessment and are dependent on the assumed solid-aqueous phase partitioning coefficient (kd) for the radionuclide. Source leachate activities in the table below are EMDF Performance Assessment estimates of activities of radionuclides in landfill wastewater at landfill closure in FY 2047. Activities of radionuclides in landfill wastewater between now and FY 2047 should be higher.

PRG in secular equilibrium (SE) and isotope only columns were calculated using the EPA radionuclide PRG calculator available at https://epa-prgs.ornl.gov/cgi-bin/radionuclides/rprg_search.

Radionuclides for which PRGs are include in EMDF PRG Development Table 1 are bolded in red font.

All isotopes that the EMDF Performance Assessment predicts being in landfill wastewater at landfill closure in FY2047 are not accounted for in the EMDF PRG Development, Table 1 Fish Tissue and Surface Water PRGs.

Isotope	Screening Source Concentration (pCi/g)	Source Leachate Concentration (pCi/L) at T=0 (FY 2047)	HalfLife (year)	PRG at SE (pCi/g)	Isotope Only PRG
	PA Table ES.2	PA Table C.5	PA Table C.5	17.5 g/day, 365 d/yr, 26 yrs	17.5 g/day, 365 d/yr, 26 yrs
Ac-227	4.89E+04	1.44E-01	2.18E+01	9.21E-02	2.45E-01
Am-241	**2.30E+03**	**2.95E+01**	**4.32E+02**	**5.80E-02**	**4.51E-01**
Am-243	2.29E+01	1.48E+00	7.38E+03	4.66E-02	4.50E-01
Ba-133	2.71E+01	5.67E+01	1.05E+01	6.36E+00	6.36E+00
Be-10	7.16E+05	6.32E-05	1.51E+06	5.85E+00	5.85E+00
C-14	**6.27E+05**	**2.45E+03**	**5.73E+03**	**3.01E+01**	**3.01E+01**
Ca-41	4.11E+06	2.77E+00	1.02E+05	1.18E+02	1.18E+02
Cd-113m	1.11E+05		1.36E+01	1.64E+00	1.64E+00
Cf-249	3.92E-04	5.39E-05	3.51E+02	4.49E-02	3.69E-01
Cf-250	1.70E-02	3.66E-04	1.31E+01	1.28E-02	5.22E-01

Cf-251	7.36E-05	1.04E-05	8.98E+02	3.78E-02	3.57E-01
Cf-252	1.25E+03	6.48E-06	2.60E+00	2.06E-02	3.30E-01
Cl-36	**1.00E+00**		**3.01E+05**	**1.36E+01**	**1.36E+01**
Cm-243	4.37E+01	2.13E+01	2.85E+01	4.72E-02	4.87E-01
Cm-244	5.26E+05	6.23E+03	1.81E+01	2.56E-02	5.55E-01
Cm-245	9.80E+01	1.89E+00	8.50E+03	5.12E-02	4.45E-01
Cm-246	1.97E+00	7.86E+00	4.73E+03	1.31E-02	4.53E-01
Cm-247	2.35E+01	5.14E-01	1.56E+07	4.23E-02	4.66E-01
Cm-248	2.29E+01	2.76E-02	3.39E+05	2.12E-02	1.01E-01
Co-60	**1.93E+06**	**5.00E-02**	**5.27E+00**	**2.70E+00**	**2.70E+00**
Cs-134	1.39E+05	< 1.0E-06	2.10E+00	1.16E+00	1.16E+00
Cs-135	2.46E+06		2.30E+06	7.71E+00	7.71E+00
Cs-137	**3.82E+08**	**7.87E+02**	**3.00E+01**	**1.61E+00**	**1.61E+00**
Eu-152	5.84E+05	1.42E+03	1.33E+01	1.45E+00	7.23E+00
Eu-154	**7.85E+05**	**3.21E+02**	**8.80E+00**	**4.25E+00**	**4.25E+00**
Eu-155	9.98E+05	3.33E-01	4.80E+00	2.13E+01	2.13E+01
Fe-55	4.71E+07	1.99E-06	2.70E+00	5.20E+01	5.20E+01
H-3	**4.84E+06**	**2.10E+04**	**1.24E+01**	**4.18E+02**	**4.18E+02**
I-129	**4.86E+05**	**1.58E+02**	**1.57E+07**	**3.06E-01**	**3.06E-01**
K-40	5.65E+01	2.15E+02	1.28E+09	1.76E+00	1.76E+00
Kr-85	1.16E+08		1.10E+01	-	-
Mo-100	2.55E-03	9.29E-05	8.50E+18		
Mo-93	4.99E+03	8.58E+00	4.00E+03	1.21E+01	1.55E+01
Na-22	5.96E-01	1.57E-04	2.60E+00	4.77E+00	4.77E+00
Nb-93m	3.00E+03	4.64E+00	1.61E+01	4.95E+01	4.95E+01
Nb-94	1.90E+05	3.25E-01	2.03E+04	5.42E+00	5.42E+00
Ni-59	1.55E+06	3.04E+00	7.50E+04	1.56E+02	1.56E+02
Ni-63	1.03E+07	6.73E+02	9.60E+01	6.21E+01	6.21E+01
Np-237	**5.63E+01**	**1.61E+01**	**2.14E+06**	**6.65E-02**	**7.27E-01**
Pa-231	3.17E+00	1.19E+00	3.28E+04	6.85E-02	2.67E-01
Pb-210	4.48E+02	7.33E+01	2.23E+01	1.75E-02	5.12E-02
Po-210	SE with Pb-210	7.4E+01		2.67E-02	2.67E-02
Pd-107	3.34E+06		6.50E+06	1.58E+02	1.58E+02
Pm-146	1.24E-01	2.15E-04	5.50E+00	2.55E+00	1.02E+01
Pm-147	2.67E+06	5.36E-04	2.60E+00	1.20E+00	2.43E+01
Pu-238	**7.15E+03**	**4.64E+03**	**8.77E+01**	**1.39E-02**	**3.55E-01**
Pu-239	**1.85E+05**	**2.88E+03**	**2.41E+04**	**5.23E-02**	**3.46E-01**
Pu-240	**8.44E+03**	**3.07E+03**	**6.54E+03**	**2.68E-02**	**3.46E-01**
Pu-241	2.83E+05	1.01E+04	1.44E+01	5.78E-02	2.64E+01
Pu-242	4.98E+01	8.56E+00	3.76E+05	1.35E-02	3.63E-01
Pu-244	1.11E+01	1.82E-01	8.26E+07	2.46E-02	3.20E-01
Ra-226	**1.35E+01**	**5.34E-01**	**1.60E+03**	**1.52E-02**	**1.17E-01**

Ra-228	**3.46E+00**	**1.47E-02**	**5.75E+00**	**3.25E-02**	**4.23E-02**
Re-187	1.94E-03	8.46E-05	4.12E+10	2.52E+03	2.52E+03
Sb-125	1.37E+06	< 1.0E-06a	2.80E+00	8.24E+00	9.69E+00
Se-79	2.47E+06		6.50E+04	6.56E+00	6.56E+00
Sm-151	5.75E+06		9.00E+01	7.40E+01	7.40E+01
Sn-121m	6.41E+01		5.50E+01	1.17E+01	1.75E+01
Sn-126	1.89E+06		1.00E+05	1.50E+00	1.61E+00
Sr-90	**3.93E+08**	**1.26E+04**	**2.91E+01**	**6.32E-01**	**8.75E-01**
Tc-99	**1.35E+06**	**2.69E+03**	**2.13E+05**	**1.51E+01**	**1.51E+01**
Th-228	**1.14E+05**	**1.41E-06**	**1.90E+00**	**1.42E-01**	**4.07E-01**
Th-229	3.48E+03	3.81E+00	7.34E+03	8.40E-02	2.07E-01
Th-230	**1.48E+02**	**1.28E+00**	**7.70E+04**	**1.48E-02**	**5.05E-01**
Th-232	**2.67E+06**	**2.35E+00**	**1.41E+10**	**3.04E-02**	**4.52E-01**
U-232	8.43E+05	4.04E+02	7.20E+01	7.45E-02	1.56E-01
U-233	**5.49E+05**	**1.65E+03**	**1.59E+05**	**7.40E-02**	**6.21E-01**
U-234	**1.67E+03**	**2.50E+04**	**2.45E+05**	**1.44E-02**	**6.31E-01**
U-235	**2.57E+03**	**1.57E+03**	**7.04E+08**	**6.16E-02**	**6.38E-01**
U-236	**4.87E+02**	**3.56E+02**	**2.34E+07**	**2.90E-02**	**6.70E-01**
U-238	**2.07E+09**	**1.51E+04**	**4.47E+09**	**1.40E-02**	**6.95E-01**
Zr-93	5.56E+05		1.53E+06	2.32E+01	4.28E+01

23) The EMDF PA includes screening level activities of 382,000,000 pCi/g of Cs-137 and 2,460,000 pCi/g for Cs-135. Where Cs-137 has a half-life of about 30 years, Cs-135 has a half-life of about 2,300,000 years. Geometric mean freshwater to fish transfer factors for Cs-137 and Cs-135 are about 1,700 L/kg (IAEA,2015) and the ORNL Risk Assessment Information System (RAIS) shows bioconcentration factors for these isotopes at 2,500 L/kg. This means Cs-135 and Cs-137 discharged to surface water likely transfers to and bioconcentrate in fish. With the Cs-135 half-life, activities of Cs-135 are not going to significantly decrease due to radioactive decay in the next few million years. Since the Fukushima Daiichi Nuclear Power Plant accident, there have been a series of articles published concerning Cs-135/Cs-137 ratios including at least one from the Idaho National Laboratory[xiv]. Many of these articles reference limitations to measuring Cs-135. Just because Cs-135 may be hard to reliably measure does not mean it is not present. Just because Cs-135 may be hard to measure does not mean any cancer risk from Cs-135 should not be incorporated into the remedial action to ensure ARARs and the required CERCLA risk range are not exceeded.

24) EMDF PRG Development includes the assumption on page 1 that "radionuclides of interest were either received or generated at the ORR without their progeny (e.g., uranium was milled and refined, transuranics, and fission products produced from reactor operations.)" The proposed process of evaluating radioactive decay chains in secular equilibrium and segmenting chains for portions in equilibrium for measurement purposes makes sense and helps account for progeny. **However, the list of radionuclides does not account for all radionuclide isotopes produced at ORR including at ORNL. Mischaracterization of isotopes generated or produced at ORR as progeny and not accounting for them separately likely underestimates the cancer**

risk.

For example, consider Radium-226 (Ra-226) secular equilibrium proposed in EMDF PRG Development. Radium-226 (Ra-226) identified on page 2 of EMDF PRG Development is identified as reaching secular equilibrium (SE) with progeny within 160 years. Secular equilibrium of Ra-226 is proposed to account for progeny including Lead-210 (Pb-210) and Polonium-210 (Po-210). Ra-226 proposed for disposal in a future EMDF is identified in EMDF Performance Assessment Table B.5 as containing an average activity of 2.92 pCi/g (decayed to 2047) in ORNL D&D waste. Based on analysis run at https://epa-prgs.ornl.gov/cgi-bin/radionuclides/chain.pl at about 100 years of radioactive decay 2.92 pCi/g of Ra-226, should have about 2.82 pCi/g of progeny Pb-210 and Po-210. In this example, if the decay is less than 100 years, Pb-210 and Po-210 progeny will be smaller.

Time (yrs)	Ra-226	Rn-222	Po-218	At-218	Rn-218	Pb-214	Bi-214	Po-214	Tl-210	Pb-210	Bi-210	Po-210	Hg-206	Tl-206
0	3.05													
0.0001	3.05	0.02	0.018	3.68E-06	3.7E-09	7.90E-03	3.30E-03	3.29E-03	6.32E-07	2.8E-09	2.8E-12	9E-17	3E-17	1.9E-17
0.001	3.05	0.195	0.194	3.87E-05	3.87E-08	0.18	0.169	0.169	3.54E-05	2.3E-06	3.4E-08	1E-11	4E-14	8.4E-14
0.01	3.05	1.48	1.47	2.95E-04	2.95E-07	1.47	1.46	1.46	3.07E-04	2.49E-04	3.84E-05	2E-07	5E-12	5.5E-11
0.1	3.05	3.04	3.04	6.09E-04	6.09E-07	3.04	3.04	3.04	6.39E-04	0.00805	0.00622	4E-04	2E-10	8.4E-09
0.5012	3.05	3.05	3.05	6.09E-04	6.09E-07	3.05	3.05	3.05	6.40E-04	0.0459	0.044	0.014	9E-10	5.90E-08
1	3.05	3.05	3.05	6.09E-04	6.09E-07	3.05	3.05	3.05	6.40E-04	0.0923	0.0904	0.048	2E-09	1.21E-07
1.259	3.05	3.05	3.05	6.09E-04	6.09E-07	3.05	3.05	3.05	6.40E-04	0.116	0.114	0.069	2E-09	1.53E-07
1.585	3.05	3.05	3.05	6.09E-04	6.09E-07	3.05	3.05	3.05	6.40E-04	0.146	0.144	0.097	3E-09	1.93E-07
1.995	3.05	3.05	3.05	6.09E-04	6.09E-07	3.04	3.05	3.04	6.40E-04	0.183	0.181	0.133	3E-09	2.42E-07
2.512	3.04	3.04	3.04	6.09E-04	6.09E-07	3.04	3.04	3.04	6.39E-04	0.228	0.227	0.178	4E-09	3.04E-07
3.162	3.04	3.04	3.04	6.09E-04	6.09E-07	3.04	3.04	3.04	6.39E-04	0.285	0.283	0.235	5E-09	3.79E-07
3.981	3.04	3.04	3.04	6.09E-04	6.09E-07	3.04	3.04	3.04	6.39E-04	0.355	0.353	0.306	7E-09	4.73E-07
5.012	3.04	3.04	3.04	6.08E-04	6.08E-07	3.04	3.04	3.04	6.39E-04	0.44	0.438	0.393	8E-09	5.87E-07
10	3.03	3.03	3.03	6.07E-04	6.07E-07	3.03	3.03	3.03	6.37E-04	0.814	0.813	0.774	2E-08	1.09E-06
25.119	3.02	3.02	3.02	6.03E-04	6.03E-07	3.01	3.02	3.01	6.33E-04	1.65	1.64	1.62	3E-08	2.20E-06
50.119	2.98	2.98	2.98	5.97E-04	5.97E-07	2.98	2.98	2.98	6.26E-04	2.38	2.38	2.37	5E-08	3.18E-06
100 FY2047	**2.92**	**2.92**	**2.92**	**5.84E-04**	**5.84E-07**	**2.92**	**2.92**	**2.92**	**6.13E-04**	2.82	**2.82**	2.82	**5E-08**	**3.78E-06**
160	2.84	2.84	2.84	5.69E-04	5.69E-07	2.84	2.84	2.84	5.97E-04	2.86	2.86	2.86	5E-08	3.83E-06

The problem is that Pb-210 identified in EMDF Performance Assessment Table B.5 contains an estimated average activity of 46.8 pCi/g (decayed to FY 2047) in ORNL D&D waste, not 2.82

pCi/g. Based on analysis run at https://epa-prgs.ornl.gov/cgi-bin/radionuclides/chain.pl at secular equilibrium with 46.8 pCi/g of Pb-210, there should also be activity concentrations of Po-210 of about 47.6 pCi/g. Between now and landfill closure in FY 2047, Pb-210 and Po-210 activity concentrations will be higher. In the table below, note that Pb-210 and its progeny Po-210 reach secular equilibrium in about 2 ½ to 3 years.

	Time (yrs)	Pb-210	Bi-210	Po-210	Hg-206	Tl-206
FY 1947	0	1060				
	0.0001	1060	5.34	5E-04	2E-05	2.6E-05
	0.001	1060	52.2	0.048	2E-05	8.8E-05
	0.01	1060	420	4.14	2E-05	0.00058
	0.1	1060	1050	144	2E-05	0.00141
	0.5012	1040	1050	615	2E-05	0.0014
	1	1030	1030	867	2E-05	0.00138
	1.259	1020	1020	927	2E-05	0.00137
	1.585	1010	1010	966	2E-05	0.00135
	1.995	997	998	986	2E-05	0.00134
	2.512	981	982	987	2E-05	0.00131
	3.162	961	962	975	2E-05	0.00129
	3.981	937	938	953	2E-05	0.00126
	5.012	908	908	924	2E-05	0.00122
	10	777	777	791	1E-05	0.00104
	25.119	484	485	493	9E-06	0.00065
	50.119	222	222	226	4E-06	0.0003
	63.096	148	148	151	3E-06	0.0002
	79.433	88.9	89	90.5	2E-06	0.00012
FY 2047	**100**	46.8	**46.8**	47.6	**9E-07**	**6.3E-05**
	125.893	20.8	20.9	21.2	4E-07	2.8E-05
	158.489	7.54	7.54	7.67	1E-07	1E-05
	160	7.19	7.19	7.32	1E-07	9.6E-06

The following table gives secular equilibrium of Ra-226 in EMDF PRG Development including individual isotope contribution to the fish consumption PRG and instream activity PRG in EMDF PRG Development Table 1. To be consistent with EMDF PRG Development, this example used a fish ingestion rate of 17.5 grams per day, 365 days per year for 26 years. This equates to eating about 28 8-ounce servings of fish per year. This example also used both ORNL RAIS and EMDF Performance Assessment assumed soil and waste to water partitioning coefficients (kd) to estimate concentrations in waste that may give a 10-5 risk from eating fish. Waste activities include a dilution factor of 3.95 to account for dilution of an estimated 30 gpm discharge into a 30-day 5-year recurrent flow. The 30-gpm discharge flow is from the Focus Feasibility for Water Management Table 3 Landfill Wastewater Flow Rates. Instream flow of 88.4 gpm at BCK 7.87 was calculated from USGS StreamStats estimated 0.197 cfs. 30 day 5-year recurrent flow interval was used because TDEC Rule 0400-40-03-.05(4) requires this flow

for setting discharge standards for recreational use and pursuant to EPA Administrator Wheeler's decision on the Focus Feasibility for Water Management, this rule is a relevant and appropriate requirement for setting discharge standards for radionuclides.

	Fish Consumption PRG, TR=10-5 (pCi/g)	BCF (L/kg)	Instream Activity pCi/L	ORNL RAIS Kd (L/Kg)	EMDF PA Assumed waste Kd (L/Kg)	Waste Activity Using RAIS Kd that equates to TR=10-5 (pCi/g)	Waste Activity Using EMDF PA Assumed Waste Kd that equates to TR=10-5 (pCi/g)
Ra-226 SE	0.0152						
Individual Isotopes							
Ra-226	0.117	4	29.3	1	1500	0.116	173
Rn-222	-						
Po-218	-						
At-218	-						
Rn-218	-						
Pb-214	124	25	4,960	150	50	2,940	980
Bi-214	227	15	15,100	480		28,700	
Po-214	-						
Tl-210	-						
Pb-210	0.051	25	2.05	150	50	1.21	0.4
Bi-210	4.62	15	308	480		584	
Po-210	0.027	36	0.742	210		0.615	
Hg-206	-						
Tl-206	-						
Combined instream Surface Water PRG			0.534				

The assumed soil or waste to water partitioning coefficient (kd) is another significant uncertainty. In the above example assumed Kd values change the activity concentration of Ra-226 in waste by three orders of magnitude. Depending on the Kd selected, in this example, Ra-226 activity in waste that may correspond with a 10-5 cancer risk level in fish varies from 0.116 to 173 pCi/g.

To evaluate this another way, for this example, let's assume waste containing Ra-226 achieves secular equilibrium (SE) with its progeny. In FY 2047, EMDF Performance Assessment Table B.5 shows ORNL D&D Ra-226 activity decays to 2.92 pCi/g. At secular equilibrium (SE), there should also be about 2.82 pCi/g of both Pb-210 and Po-210. The following table incorporates the same BCF values, 3.95 dilution factor, and exposure assumptions as the above table.

Pb-210 was evaluated in SE with progeny Po-210 because Pb-210 in fish appears to approach SE with Po-210 in about 2 ½ to 3 years. Po-210 is also included separately because while the landfill is accepting ORNL waste and landfill wastewater is not treated for radionuclides, the quantity of Po-210 in fish should be the sum of Po-210 decayed from Pb-210 and additional Po-210 transferred from surface water to fish. Further, Pb-210 has a half-life of 22.3 years, therefore once it is in fish, it will pose an excess cancer risk to human health from eating fish with Pb-210 and its progeny Po-210 for many years after release of wastewater associated with ORNL D&D stops or effective treatment of landfill wastewater begins.

Individual or SE	Isotope	Waste activity (pCi/g)	EMDF PA assumed Waste Kd (L/kg)	ORNL RAIS kd (L/kg)	Instream Activity @ Kd in EMDF PA (pCi/L)	Instream Activity @ RAIS Kd (pCi/L)	Fish Activity, Kd in EMDF PA (pCi/g)	Fish Activity, RAIS Kd (pCi/g)	Cancer Risk @ EMDF PA Kd	Cancer Risk @ RAIS Kd
Individual	Ra-226	2.92	1500	1	0.49	739	0.00197	2.96	1.68E-07	2.53E-04
SE	Pb-210	2.82	50	150	14.3	4.76	0.357	0.119	2.04E-04	6.80E-05
Individual	Po-210	2.82		210		3.4	SE with Pb-210	0.122	1.34E-04	4.57E-05
Risk Sum									3.38E-04	3.67E-04

Now consider the same ORNL D&D waste where it is not assumed Pb-210 is progeny and Pb-210 activity in waste estimated in the EMDF Performance Assessment is included.

Individual or SE	Isotope	Waste activity (pCi/g)	EMDF PA assumed Waste Kd (L/kg)	ORNL RAIS kd (L/kg)	Instream Activity @ Kd in EMDF PA (pCi/L)	Instream Activity @ RAIS Kd (pCi/L)	Fish Activity, Kd in EMDF PA (pCi/g)	Fish Activity, RAIS Kd (pCi/g)	Cancer Risk @ EMDF PA Kd	Cancer Risk @ RAIS Kd
Individual	Ra-226	2.92	1500	1	0.49	739	0.00197	2.96	1.68E-07	2.53E-04
SE	Pb-210	46.8	50	150	237	79	5.92	1.97	3.39E-03	1.13E-03
Individual	Po-210	47.6		210		57.4	SEwith Pb-210	2.07	2.22E-03	7.75E-04
Risk Sum									5.61E-03	2.16E-03

The above example, using ORNL D&D waste activities decayed to FY 2047 presented in the EMDF Performance Assessment, shows that assuming radionuclides produced at ORR are progeny and not produced at ORR underestimates the cancer risk.

25) A comment to the Waste Acceptance Criteria fact sheet is that as shown in the above example, the assumed kd can dramatically impact the cancer risk associated with eating fish. This demonstrates the significant uncertainty that assumed kds add to calculating waste acceptance criteria that protects groundwater and surface water users.
26) Comments concerning Ra-226 also show that analyzing fish samples for Ra-226 and not also analyzing for Pb-210 and Po-210 likely underestimates risk from Pb-210 and Po-210 at ORR.

These comments are respectfully submitted by:

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EMDF Comments Primarily Related to Radionuclide Discharge Limits
Water Quality Protection of Bear Creek Fact Sheet
Due DOE June 7, 2022

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[i] Performance Assessment for the Environmental Management Disposal Facility at the Y-12 National Security Complex, Oak Ridge, Tennessee (UCOR-5094/R2)

[ii] Composite Analysis for the Environmental Management Waste Management Facility and the Environmental Management Disposal Facility, Oak Ridge, Tennessee (UCOR-5095/R2)

[iii]

Table B.6. Total EMDF radionuclide inventory (Ci decayed to 2047) (cont.)

Waste mass (g)	ORNL D&D 1.94E+11	ORNL RA 1.81E+11	Y-12 D&D Alpha-4 and Alpha-5 1.37E+11	Y-12 D&D Biology 2.81E+10	Y-12 D&D Remaining Facilities 3.03E+11	Y-12 RA 5.26E+11	EMDF Waste Total Inventory (Ci) 1.37E+12	EMDF waste average activity concentration (pCi/g)
Radio-isotope	EMDF activity by waste stream (Ci)							
Na-22	2.09E-06	2.63E-08					2.12E-06	1.55E-06
Nb-93m	Refer to Attachment B.3 for basis of inventory estimate						6.01E-01	4.39E-01
Nb-94	4.20E-02						4.20E-02	3.07E-02
Ni-59	7.84E+00						7.84E+00	5.73E+00
Ni-63	1.17E+02	1.62E+03		4.84E-02			1.74E+03	1.27E+03
Np-237	8.92E-02	5.08E-01	6.72E-03	6.04E-03		2.27E-01	8.37E-01	6.12E-01
Pa-231	6.15E-01						6.15E-01	4.49E-01
Pb-210	9.09E+00	4.08E-01					9.50E+00	6.93E+00
Pm-146	2.28E-04						2.28E-04	1.66E-04
Pm-147	5.49E-04	1.69E-05					5.66E-04	4.13E-04
Pu-238	1.43E+02	9.86E+01	2.52E-02		1.20E-01	4.62E-03	2.42E+02	1.77E+02
Pu-239	4.61E+01	1.04E+02			2.31E-02	3.12E-01	1.50E+02	1.10E+02
Pu-240	6.81E+01	9.18E+01	9.29E-03	5.07E-03			1.60E+02	1.17E+02
Pu-241	1.33E+01	5.12E+02					5.25E+02	3.83E+02
Pu-242	3.55E-02	4.10E-01					4.45E-01	3.25E-01
Pu-244	9.49E-03						9.49E-03	6.93E-03
Ra-226	5.68E-01	7.08E-01		2.80E-02		7.63E-01	2.07E+00	1.51E+00
Ra-228	1.27E-03	2.52E-03			5.17E-02	1.41E-03	5.69E-02	4.15E-02
Re-187	4.40E-06						4.40E-06	3.21E-06
Sb-125	7.82E-08						7.82E-08	5.71E-08
Sr-90	4.21E+02	7.50E+01		4.93E-02	5.02E-02		4.96E+02	3.62E+02
Tc-99	2.57E+00	7.11E-01	1.48E-01	1.14E+00	2.36E-01	2.43E+00	7.23E+00	5.28E+00
Th-228	2.25E-07	3.40E-10	8.14E-08	3.58E-07	4.78E-06		5.45E-06	3.98E-06
Th-229	3.36E-01	1.44E+01			1.43E-02		1.47E+01	1.08E+01
Th-230	3.30E-01	3.81E+00	5.92E-02		2.38E-02	7.20E-01	4.94E+00	3.61E+00
Th-232	2.32E-01	1.69E+00	5.14E-02	2.24E-02	1.98E-01	6.87E+00	9.07E+00	6.62E+00
U-232	1.62E-01	2.61E+01					2.63E+01	1.92E+01
U-233	5.15E+01	5.27E+01		2.71E+00	3.33E-01		1.07E+02	7.83E+01
U-234	2.15E+00	2.72E+01	1.25E+00	2.34E+00	1.58E+03	8.24E+00	1.62E+03	1.19E+03
U-235	8.15E-02	4.23E-01	1.02E-01	2.02E-01	9.57E+01	5.84E+00	1.02E+02	7.47E+01
U-236	5.14E-02	1.95E-01	5.22E-02	1.19E-01	2.26E+01	1.19E-01	2.32E+01	1.69E+01
U-238	1.32E+00	5.27E+00	4.71E+00	9.56E+00	8.83E+02	7.92E+01	9.83E+02	7.18E+02

D&D = deactivation and decommissioning
EMDF = Environmental Management Disposal Facility
ORNL = Oak Ridge National Laboratory
RA = remedial action
Y-12 = Y-12 National Security Complex

Table B.6. Total EMDF waste radionuclide inventory (Ci decayed to 2047)

Waste mass (g)	ORNL D&D 1.94E+11	ORNL RA 1.81E+11	Y-12 D&D Alpha-4 and Alpha-5 1.37E+11	Y-12 D&D Biology 2.81E+10	Y-12 D&D Remaining Facilities 3.03E+11	Y-12 RA 5.26E+11	EMDF Waste Total Inventory (Ci) 1.37E+12	EMDF waste average activity concentration (pCi/g)
Radio-isotope	EMDF activity by waste stream (Ci)							
Ac-227	7.54E-03						7.54E-03	5.50E-03
Am-241	4.09E+01	1.11E+02	2.20E-03	5.11E-03	1.80E-02	3.61E-01	1.52E+02	1.11E+02
Am-243	5.30E-01	7.12E+00					7.65E+00	5.59E+00
Ba-133	Refer to Attachment B.3 for basis of inventory estimate						4.14E+00	3.02E+00
Be-10	Refer to Attachment B.3 for basis of inventory estimate						6.52E-05	4.76E-05
C-14	1.66E+00	4.60E+00		1.17E+00			7.43E+00	5.43E+00
Ca-41	Refer to Attachment B.3 for basis of inventory estimate						1.09E-01	7.92E-02
Cf-249	2.80E-06						2.80E-06	2.05E-06
Cf-250	1.91E-05						1.91E-05	1.39E-05
Cf-251	5.42E-07						5.42E-07	3.96E-07
Cf-252	3.37E-07						3.37E-07	2.46E-07
Cm-243	1.01E+00	1.02E-01					1.11E+00	8.10E-01
Cm-244	3.23E+02	2.53E+00	5.39E-04				3.26E+02	2.38E+02
Cm-245	9.87E-02						9.87E-02	7.21E-02
Cm-246	4.10E-01						4.10E-01	2.99E-01
Cm-247	2.68E-02						2.68E-02	1.96E-02
Cm-248	1.44E-03						1.44E-03	1.05E-03
Co-60	4.23E-02	7.90E-03	8.87E-04			4.20E-04	5.15E-02	3.76E-02
Cs-134	5.41E-09	2.19E-08					2.73E-08	1.99E-08
Cs-137	4.11E+02	2.63E+03	2.73E-02	3.71E-03	1.42E-02	2.84E+00	3.04E+03	2.22E+03
Eu-152	7.25E+01	1.46E+00					7.40E+01	5.40E+01
Eu-154	1.65E+01	2.52E-01					1.67E+01	1.22E+01
Eu-155	1.72E-02	1.44E-04					1.74E-02	1.27E-02
Fe-55		2.31E-06					2.31E-06	1.68E-06
H-3	2.52E+01	3.56E+00		6.25E-02			2.88E+01	2.10E+01
I-129	9.56E-01	9.35E-02					1.05E+00	7.66E-01
K-40	1.07E+00	3.43E+00		6.27E-01		3.33E+00	8.46E+00	6.18E+00
Mo-100	1.08E-05						1.08E-05	7.92E-06
Mo-93	Refer to Attachment B.3 for basis of inventory estimate						1.00E+00	7.30E-01

[iv] A Review of the Performance Assessment and Composite Analysis for the Proposed Environmental Management Disposal Facility, Oak Ridge, Tennessee, October 12, 2020 (NAC-0131_R1)

[v] Development of Fish Tissue and Surface Water Preliminary Remediation Goals for Radionuclides of Interest for the Proposed Environmental Management Disposal Facility, Oak Ridge, Tennessee (UCOR-5550)

[vi] Development of Fish Tissue and Surface Water Preliminary Remediation Goals for Radionuclides of Interest for the Proposed Environmental Management Disposal Facility, Oak Ridge, Tennessee (UCOR-5550)

[vii] Radiation Risk Assessment At CERCLA Sites: Q & A Directive 9200.4-40, EPA 540-R-012-13, May 2014 specifies that "[a]t CERCLA remedial sites, excess cancer risk from both radionuclides and chemical carcinogens should be summed to provide an estimate of the combined risk presented by all carcinogenic contaminants as specified in OSWER directive 9200.4-18 (U.S. EPA 1997a)."

[viii] EPA Administrator Wheeler's December 31, 2020, final dispute decision footnote specifies that *"For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10–4 and 10–6 using information on the relationship between dose and response. 40 C.F.R. § 300.430(e)(2)(i)(A)(2). See also 55 Fed. Reg. 8666, 8717-8718 (Mar. 8, 1990)."*

[ix] https://www.tn.gov/content/dam/tn/environment/water/tn-h2o/documents/plan-%26-appendices/wr-tnh2o_plan-report.pdf

[x] CERCLA at 42 U.S. Code § 9621(d)(1) requires that "Remedial actions selected under this section or otherwise required or agreed to by the President under this chapter shall attain a degree of cleanup of hazardous substances, pollutants, and contaminants released into the environment and of control of further release at a minimum which assures protection of human health and the environment." (Emphasis added)

[xi]

Location	Common Name	Date Collected	Results	Units	Results Qualifier	Detection Limit	Rad Error
BCK 3.3	rock bass	5/12/2021	1.0065	pCi/g		0.128	0.254
EFK 0.0	redbreast sunfish	5/18/2021	0.339	pCi/g		0.261	0.204
BFK 7.6	redbreast sunfish	5/26/2021	0.298	pCi/g		0.244	0.187
BFK 7.6	rock bass	5/26/2021	0.294	pCi/g		0.123	0.117
EFK 0.0	bluegill sunfish	5/18/2021	0.277	pCi/g		0.0774	0.0862
BFK 7.6	bluegill sunfish	5/26/2021	0.261	pCi/g		0.154	0.153
BFK 7.6	warmouth sunfish	5/26/2021	0.238	pCi/g	J	0.286	0.191
BFK 7.6	warmouth sunfish	5/26/2021	0.207	pCi/g		0.191	0.144
BFK 7.6	redbreast sunfish	10/20/2021	0.189	pCi/g		0.0902	0.098
BCK 0.5	redbreast sunfish	10/27/2021	0.177	pCi/g		0.122	0.101
BCK 3.3	redbreast sunfish	11/3/2021	0.157	pCi/g		0.129	0.0982
EFK 0.0	walleye	5/18/2021	0.1538	pCi/g		0.0453	0.0713
BFK 7.6	rock bass	10/20/2021	0.149	pCi/g		0.127	0.0982
EFK 0.0	spotted bass	5/18/2021	0.148	pCi/g		0.132	0.0965
EFK 0.0	warmouth sunfish	5/18/2021	0.146	pCi/g	J	0.151	0.106
BCK 0.5	rock bass	5/17/2021	0.14	pCi/g		0.122	0.0963
BCK 0.5	largemouth bass	10/27/2021	0.136	pCi/g	J	0.178	0.116
BFK 7.6	rock bass	5/26/2021	0.135	pCi/g		0.0925	0.0803
BFK 7.6	redbreast sunfish	5/26/2021	0.131	pCi/g	J	0.201	0.128
BFK 7.6	rock bass	5/26/2021	0.131	pCi/g		0.0716	0.0734
EFK 0.0	yellow bass	5/18/2021	0.129	pCi/g		0.103	0.0843
BCK 0.5	rock bass	10/27/2021	0.124	pCi/g	J	0.172	0.11
EFK 0.0	bluegill sunfish	10/26/2021	0.123	pCi/g	J	0.127	0.0881
BCK 0.5	rock bass	5/17/2021	0.122	pCi/g		0.0586	0.0636
BCK 3.3	rock bass	5/25/2021	0.121	pCi/g		0.071	0.0704
EFK 0.0	bluegill sunfish	10/26/2021	0.12	pCi/g		0.0962	0.0787
BCK 0.5	green sunfish	5/17/2021	0.117	pCi/g		0.0747	0.0716
BCK 0.5	largemouth bass	5/17/2021	0.112	pCi/g		0.0657	0.0652
BCK 3.3	rock bass	5/25/2021	0.11	pCi/g	J	0.144	0.094
BCK 3.3	green sunfish	5/12/2021	0.11	pCi/g	J	0.121	0.086
BCK 0.5	rock bass	5/17/2021	0.104	pCi/g		0.0817	0.0621
BCK 0.5	rock bass	5/17/2021	0.103	pCi/g	J	0.173	0.107
EFK 0.0	yellow bass	5/18/2021	0.102	pCi/g		0.0853	0.0636
EFK 0.0	spotted bass	10/26/2021	0.0974	pCi/g	U	0.175	0.106
BFK 7.6	bluegill sunfish	10/20/2021	0.0962	pCi/g		0.0775	0.057
EFK 0.0	white crappie	5/18/2021	0.0953	pCi/g	J	0.13	0.0855
BFK 7.6	redbreast sunfish	10/20/2021	0.0949	pCi/g		0.0568	0.052
BCK 0.5	green sunfish	5/17/2021	0.0941	pCi/g		0.0514	0.0527
BFK 7.6	rock bass	10/20/2021	0.092	pCi/g		0.0391	0.0448
BFK 7.6	rock bass	10/20/2021	0.0894	pCi/g		0.0757	0.0555

BFK 7.6	rock bass	10/20/2021	0.088	pCi/g		0.0696	0.0617
EFK 0.0	warmouth sunfish	5/18/2021	0.0877	pCi/g	J	0.0945	0.0638
BFK 7.6	rock bass	5/26/2021	0.0866	pCi/g		0.0461	0.0442
BCK 3.3	green sunfish	10/25/2021	0.0861	pCi/g		0.0366	0.0419
BCK 3.3	rock bass	11/3/2021	0.0855	pCi/g	J	0.117	0.0767
BFK 7.6	rock bass	5/26/2021	0.0814	pCi/g		0.0643	0.051
BCK 0.5	bluegill sunfish	10/27/2021	0.0791	pCi/g		0.0752	0.0524
BCK 0.5	rock bass	5/17/2021	0.0776	pCi/g	J	0.175	0.115
BCK 3.3	green sunfish	11/3/2021	0.0757	pCi/g		0.0414	0.0424
EFK 0.0	largemouth bass	10/26/2021	0.0735	pCi/g	J	0.0803	0.0544
EFK 0.0	bluegill sunfish	10/26/2021	0.0731	pCi/g		0.0311	0.0356
BCK 3.3	rock bass	11/3/2021	0.07215	pCi/g		0.0491	0.0487
EFK 0.0	largemouth bass	10/26/2021	0.0711	pCi/g	U	0.191	0.109
BCK 3.3	green sunfish	11/3/2021	0.0704	pCi/g	U	0.135	0.0809
BCK 3.3	warmouth sunfish	5/12/2021	0.0689	pCi/g	U	0.248	0.135
BFK 7.6	redbreast sunfish	5/26/2021	0.0688	pCi/g		0.0412	0.0377
BCK 0.5	rock bass	5/17/2021	0.0682	pCi/g		0.0645	0.0471
BCK 3.3	redbreast sunfish	5/12/2021	0.067	pCi/g	J	0.0684	0.0472
BCK 3.3	bluegill sunfish	11/3/2021	0.0664	pCi/g		0.0545	0.0416
BCK 0.5	rock bass	10/27/2021	0.0644	pCi/g	J	0.107	0.072
BCK 0.5	rock bass	5/17/2021	0.0641	pCi/g	U	0.132	0.0782
EFK 0.0	largemouth bass	10/26/2021	0.06305	pCi/g		0.0808	0.059
BFK 7.6	rock bass	5/26/2021	0.061955	pCi/g	J	0.127	0.0862
BFK 7.6	rock bass	10/20/2021	0.0609	pCi/g	J	0.0848	0.0543
BCK 3.3	redbreast sunfish	5/12/2021	0.0597	pCi/g	J	0.0653	0.0502
BCK 0.5	bluegill sunfish	10/27/2021	0.0579	pCi/g	J	0.085	0.0536
BFK 7.6	bluegill sunfish	10/20/2021	0.0578	pCi/g	U	0.311	0.165
EFK 0.0	spotted bass	10/26/2021	0.0539	pCi/g		0.0431	0.0352
BFK 7.6	redbreast sunfish	10/20/2021	0.0538	pCi/g		0.0411	0.0365
BCK 3.3	green sunfish	5/25/2021	0.0527	pCi/g	U	0.118	0.0689
BCK 3.3	redbreast sunfish	11/3/2021	0.0521	pCi/g	J	0.0524	0.0383
BCK 3.3	redbreast sunfish	11/3/2021	0.0511	pCi/g		0.0445	0.0353
EFK 0.0	white crappie	5/18/2021	0.0504	pCi/g	J	0.0675	0.0442
BCK 3.3	redbreast sunfish	5/12/2021	0.0486	pCi/g	U	0.163	0.089
BCK 3.3	redbreast sunfish	5/12/2021	0.0486	pCi/g	J	0.0544	0.0378
EFK 0.0	yellow bass	5/18/2021	0.0482	pCi/g		0.041	0.0348
BCK 0.5	redbreast sunfish	5/17/2021	0.0477	pCi/g	J	0.0571	0.0405
BCK 0.5	rock bass	10/27/2021	0.0474	pCi/g	J	0.0636	0.0416
EFK 0.0	spotted bass	5/18/2021	0.0453	pCi/g		0.0386	0.0328
EFK 0.0	bluegill sunfish	5/18/2021	0.0442	pCi/g	U	0.135	0.0755
EFK 0.0	largemouth bass	10/26/2021	0.0439	pCi/g	J	0.054	0.0365
EFK 0.0	redbreast sunfish	5/18/2021	0.0422	pCi/g	J	0.0578	0.0392

BCK 3.3	green sunfish	5/12/2021	0.0408	pCi/g	J	0.078	0.049
EFK 0.0	bluegill sunfish	10/26/2021	0.039	pCi/g	J	0.0617	0.0394
BCK 0.5	redbreast sunfish	5/17/2021	0.0372	pCi/g	U	0.119	0.0643
BFK 7.6	bluegill sunfish	5/26/2021	0.0364	pCi/g	U	0.0873	0.0505
BCK 0.5	largemouth bass	10/27/2021	0.0352	pCi/g	U	0.0712	0.0423
BCK 3.3	redbreast sunfish	11/3/2021	0.0326	pCi/g	J	0.052	0.0336
BCK 0.5	green sunfish	5/17/2021	0.0322	pCi/g	U	0.0711	0.0418
BCK 0.5	rock bass	10/27/2021	0.0316	pCi/g	U	0.0757	0.0437
EFK 0.0	yellow bass	5/18/2021	0.0311	pCi/g	J	0.0596	0.0366
EFK 0.0	yellow bass	5/18/2021	0.0297	pCi/g	J	0.0454	0.0308
EFK 0.0	walleye	5/18/2021	0.0291	pCi/g	U	0.0931	0.0504
EFK 0.0	spotted bass	10/26/2021	0.0281	pCi/g	J	0.0448	0.029
EFK 0.0	largemouth bass	10/26/2021	0.0261	pCi/g	U	0.0536	0.0319
BCK 0.5	redbreast sunfish	5/17/2021	0.0242	pCi/g	J	0.0463	0.029
BCK 3.3	largemouth bass	5/25/2021	0.0203	pCi/g	U	0.0487	0.0282
BCK 0.5	rock bass	10/27/2021	0.02	pCi/g	U	0.153	0.0783
BFK 7.6	redbreast sunfish	5/26/2021	0.0193	pCi/g	U	0.0926	0.0464
BCK 0.5	redbreast sunfish	10/27/2021	0.0192	pCi/g	U	0.0774	0.042
BFK 7.6	rock bass	10/20/2021	0.0155	pCi/g	U	0.0694	0.0366
BCK 3.3	bluegill sunfish	11/3/2021	0.00985	pCi/g	U	0.159	0.0796
EFK 0.0	bluegill sunfish	10/26/2021	0.00838	pCi/g	U	0.0603	0.0307
BFK 7.6	redbreast sunfish	10/20/2021	0.00549	pCi/g	U	0.0607	0.0285
BCK 0.5	redbreast sunfish	10/27/2021	0.00428	pCi/g	U	0.0692	0.0346
BCK 3.3	rock bass	11/3/2021	0	pCi/g	U	0.0772	0.0364
BCK 3.3	rock bass	5/25/2021	0	pCi/g	U	0.0675	0.0318
BCK 0.5	bluegill sunfish	10/27/2021	-0.00982	pCi/g	U	0.159	0.0745
BCK 3.3	largemouth bass	5/25/2021	-0.0108	pCi/g	U	0.155	0.07
BCK 3.3	green sunfish	5/25/2021	-0.0353	pCi/g	U	0.143	0.0599

[xii] Argonne National Laboratory, Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil and Building Structures (ANL/EVS/TM-14/4)

[xiii] IAEA, Technical Reports Series No. 472, Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Terrestrial and Freshwater Environments, 2010

[xiv] 137Cs activities and 135Cs/137Cs isotopic ratios from soils at Idaho National Laboratory: a case study for contaminant source attribution in the vicinity of nuclear facilities